Bread Quality and Alveograph Rheological Properties of Composite Flour Made from Flaxseed and 650 Type Wheat of Strong Quality for Bread Making

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***Abstract*—The Alveograph rheological properties and bread quality characteristics made from two flaxseed varieties (golden and brown) and 650 type wheat of strong quality for bread making were investigated. In this sense, five levels of wheat substitution (0, 5, 10, 15 and 20%) with the two varieties of flaxseed were used. It was observed that dough extensibility (range 68-23 mm) and deformation energy (range 286-120 × 10^{-4} joules) decreased significantly ($p < 0.05$) with the increased level of flaxseed flour addition in wheat flour. The loaf volume, porosity and elasticity of the bread samples increased by up to10% substitution by brown or golden flaxseed flour. From the textural point of view significant changes were observed for the hardness value which registered higher values for all the bread samples as compared to the control one. Regarding the crumb cell structure the bread with flaxseed addition seems to be less compact than that of the control sample. The bread sensory characteristics (overall acceptability, general appearance, color, flavor, texture, taste, smell) were either acceptable or better at the level of 10–15 % substitution by flaxseed flour than the sample without flaxseed addition. The Principal Component Analysis was used to show significant correlations between the chemical characteristics of wheat flour-flaxseed formulation, Alveograph rheological properties, bread physical, textural and sensory characteristics of the composite flaxseed- wheat flour. Bread overall acceptability was influenced significantly by the sensorial characteristics, general appearance and bread physical value of loaf volume. Good correlations (r=0.801) were found between bread textural characteristic hardness value and flour chemical characteristic protein content.**

***Index Terms*—wheat flour, golden flaxseed, brown flaxseed, Alveograph, bread quality**

I. Introduction

Flaxseed (also known as linseed), *Linum usitatissimum* is an important oilseed crop cultivated in two basic varieties namely golden and brown [1]. Both types are similar from the nutritional point of view except the golden flaxseed variety called Solin known with Linola name which is low in omega-3 fatty acids [2]. However in general between the two varieties slightly differences exist as the brown variety presents lower values in the amino acid content than the golden variety [3], [4] and lower values in the fatty acids content omega 3 and omega 6 [5]. Also the golden variety contains a lower amount of fiber and a higher amount of soluble carbohydrates than the brown one [6]. The most significant differences between these two varieties consist in the amount of pigment present in the seed a lower of it the lighter the seed is [7]. Flaxseed is a functional food due to the fact that it contains a high amount of essential fatty acid in especially in linolenic acid (52%), oleic acid (20%) and linoleic acid (17%) [8] the flaxseed being the leading plant source in the linolenic acid content [9]. Also flaxseed is rich in lignans, dietary fibers, proteins of a high quality (high level in the amino acids leucine, aspartic acid, glutamic acid and arginine), flavonoids and other phenolics, minerals (K, Na, P, Mg, Fe, Cu, Mn Zn) and vitamins (A, C, F and E) [9]-[11]. Due to its content in this components flaxseed consumption decrease osteoporosis and cardiovascular diseases, reduces the risk of mammary and prostate cancer, it presents anti-inflammatory activity, e.g. [12].

By addition of flaxseed in bread was obtained good results by sensorial point of view and up to 10% addition of golden or brown flaxseed and from the physical point of view [13], [14]. The wheat flour chosen in this study was of a strong quality for bread making meaning that it presents a low deformation index, a high tenacity and a low extensibility [15]. We analyzed the influence of golden and brown flaxseed in 650 type wheat flour of strong quality for bread making at five levels (0, 5, 10, 15 and 20%) of substitution on Alveograph dough rheological properties and bread quality due to it physical-chemical, textural and it sensory characteristics. Also significant correlations between chemical characteristics of wheat flour-flaxseed formulation, dough rheological properties, and bread characteristics were analyzed by using Principal Component Analysis. To our knowledge no studies have been made yet to compare the effect of the two flaxseed varieties addition on dough rheological properties by using the Alveograph device and bread quality characteristics.

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II. Materials and Methods

A. Materials

A commercial wheat (harvest 2015) and flaxseed flour of a golden and brown variety was used. The flours were analyzed according to ICC methods as fallowing: moisture content (ICC methods 110/1), ash content (ICC 104/1) and protein content (ICC 105/2). For the wheat flour was also determined: falling number (ICC 107/1), wet gluten (ICC 106/1) and gluten deformation index (SR 90:2007).

B. Alveograph Analysis

The dough rheological characteristics of the composite doughs were done using the Alveograph instrument (Chopin Technologies, France) fallowing the SR EN ISO 27971:2015 standard. The fallowing characteristics were measured: maximum pressure (*P*) representing the peak height (mm), dough extensibility (mm) indicated by length (*L*) of the alveogram curve, baking strength (*W*), index of swelling (*G*) and configuration ratio of the Alveograph curve (*P/L*).

C. Bread Samples Preparation

Bread samples were prepared from wheat and flaxseed flour of two varieties (brown and golden one) added in different doses in wheat flour as fallowing: 0% (control sample), 5%, 10%, 15% and 20%. Salt, yeast and water were added in doses of 1.5%, 3% respectively up to 56% reported to the composite flour mass. All the ingredients were mixed in a Lancom mixer for 15 minutes after which the dough was modeled and fermented for 60 minutes at temperature of 30^0C and 85% relative humidity. Thereafter the samples were baked for 30 minutes at 180 ℃ in an electrical bakery convection oven (Caboto PF8004D, Italy).

D. Physical Properties of Bread Samples

The loaf volume (determined by seed displacement method), porosity and elasticity were analyzed according to SR 91:2007.

E. Textural Properties of Bread Samples

Textural properties of bread samples analyzed were: hardness, cohesiveness, elasticity, gumminess and chewiness. For this purpose a texture analyzer Mark-10-ESM301 was used.

F. Image Analysis of the Bread Crumb Structure

Image analysis of the crumb structure of the sliced loaves was done using the MoticSMZ–140 stereo microscope with the 20x objective. The images were recorded with a resolution of 2048 x 1536 pixels.

G. Sensory Characteristics of Bread Samples

Sensory evaluation of the composite bread samples was carried out by using semi-trained panelists from Stefan cell Mare University, Faculty of Food Engineering, Romania. The panelists assessed the overall acceptability, appearance, colour, flavor, texture, taste, smell, texture using 9-point hedonic scale. A score of 1 represented "extremely dislike" and a score of 9 represented "extremely like".

H. Statistical Analysis

Statistical analysis was performed with Microsoft Excel 2007 and the Statistical Package for Social Science (SPSS, Version 16.0; IBM Corporation, Chicago, IL, USA).

III. Results and Discussion

A. Analytical Characteristcs

The wheat and flaxseed (brown and golden variety) flour analytical characteristics are shown in Table I.

TABLE I. The Analytical Characteristics of Wheat and Flaxseed Flour

Characteristics	Flour		
	Wheat	Brown flaxseed	Golden flaxseed
Moisture (%)	13.90	6.20	5.60
Ash (%)	0.65	3.50	3.41
Protein (%)	12.20	19.74	20.85
Fat (%)	1.70	42.25	41.12
Wet gluten (%)	27.5	-	-
Gluten deformation (mm)	3	-	-
Falling number (s)	325	-	-

According to the data shown in Table I, the wheat flour is of a strong quality for bread making. Due to it falling number value it presents a low alpha-amylase activity [16].

B. Alveograph Rheological Characteristcs

The Alveograph data are shown in Table II and III. As we can see for both varieties of flaxseed addition in wheat flour the dough extensibility and index of swelling decreases with the increase level of flaxseed addition. Also the baking strength decreases even more with the increase level of flaxseed addition indicating a dough weakening maybe due to the addition of a non gluten flour which will led to a gluten dilution and a decrease of it quality and quantity. However dough maximum pressure is oscillating growing slightly at high levels of flaxseed addition (as we can seen at 15% of brown flaxseed addition) probably due to the gum content from flaxseed which can led to a more uniform and dense dough.

TABLE II. The Alveograph Characteristics of Golden Flaxseed-Wheat Flour Blends

Characteristics	The levels of replacement with golden flaxseed flour of wheat flour				
	0 %	5 %	10 %	15 %	20 %
P (mm)	121	102	104	106	110
L (mm)	64	62	53	49	34
G (mm)	17.8	17.5	16.2	15.6	13.0
W (10^{-4}J)	286	223	198	173	152
P/L	1.89	1.64	1.96	2.16	3.24

TABLE III. THE ALVEOGRAPH CHARACTERISTICS OF BROWN FLAXSEED-WHEAT FLOUR BLENDS

Characteristics	The levels of replacement with brown flaxseed flour of wheat flour				
	0 %	5 %	10 %	15 %	20 %
P (mm)	121	110	107	122	110
L (mm)	64	60	58	44	35
G (mm)	17.8	17.2	17.0	14.8	12.6
W (10^{-4}J)	286	260	220	211	167
P/L	1.89	1.83	1.84	2.77	3.14

C. Bread Physical Characteristcs

In Fig. 1 are shown bread physical characteristics for the control sample and for the bread samples obtained with different levels of golden flaxseed (GFS) and brown flaxseed (BFS) added.

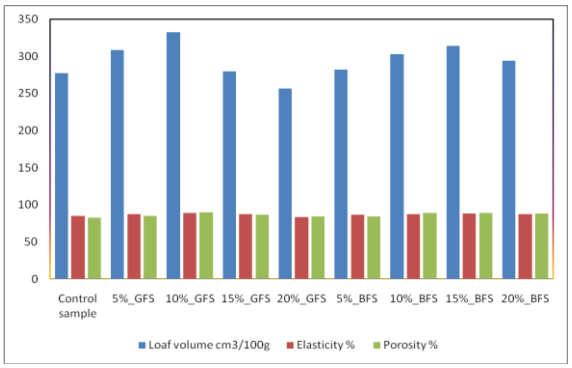

Figure 1. Bread physical characteristics

For the bread samples with GFS addition the highest values for the loaf volume, porosity and elasticity were obtained for the sample enriched with 10% golden flaxseed flour. When BFS were added the best results were obtained for the sample with 15% brown flaxseed flour. However no significant differences ($p < 0.05$) were recorded between bread samples with 10% BFS and 15% BFS addition. Also bread with 20% BSF addition presented higher values for the bread physical characteristics than those for the control one. An increase of the bread physical characteristics up to a level of flaxseed addition may be due to the high content of fat from flaxseed which probably improves dough gas retention. However at high levels of flaxseed addition the bread physical characteristics decreases due to the gluten dilution effect which increases with the increase level of wheat flour replacement with the flaxseed flour. Similar results were also obtained by [13], [17] and [18].

D. Bread Textural Properties

In Fig. 2 are shown bread textural characteristics with and without flaxseed addition. The highest value for the hardness parameter was found for bread with 20% flaxseed addition for both variety types (GSF and BSF) in agreement with the results obtained by [13]. For the elasticity all the bread samples with flaxseed in composition presented higher values than the control sample.

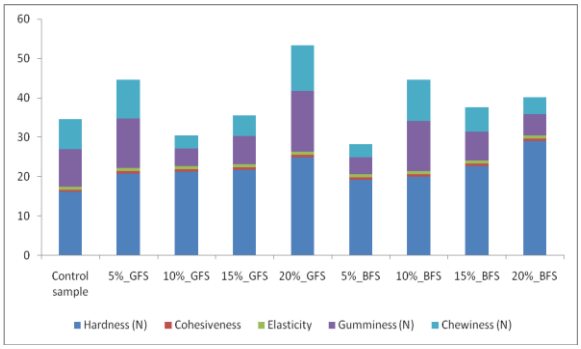

Figure 2. Effect of flaxseed flour (GSF and BSF) addition in wheat flour on textural parameters of bread samples

E. Crumb Structure of Bread Samples

Image analyses of the bread crumb structure obtained at the stereo microscope are shown in Fig. 3 (3a and 3b). At high levels of flaxseed addition (brown and golden variety) large cells can be seen the structure being less compact that the one observed at low levels at flaxseed addition.

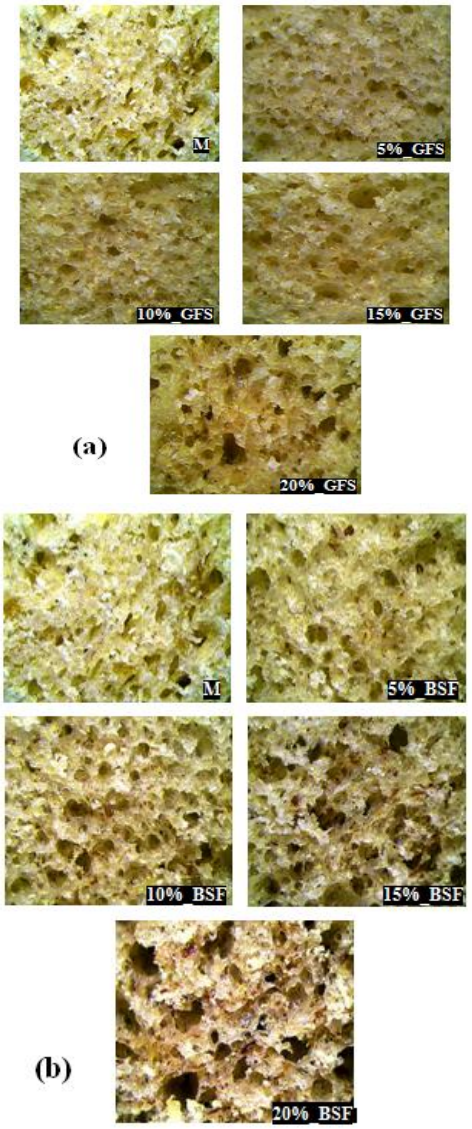

Figure 3. Crumb structure of bread samples at different levels of flaxseed addition: (a) with GSF; (b) with BSF

F. Bread Sensory Characteristics

Bread sensory characteristics are shown in Fig. 4 (4a and 4b).

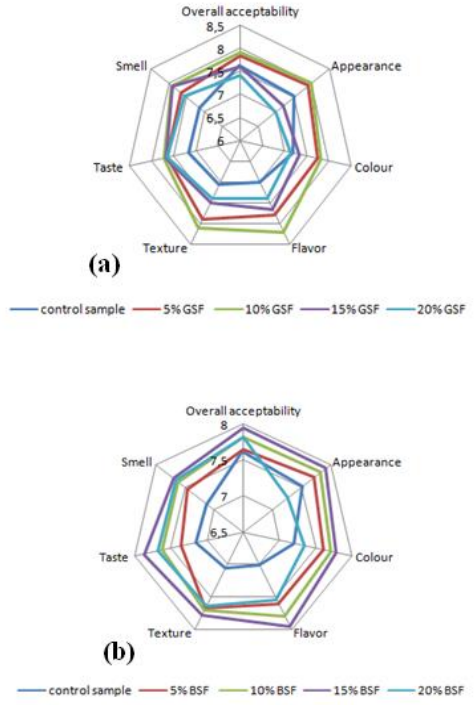

Figure 4. Sensory characteristics of bread samples at different levels of flaxseed addition: (a) with GSF; (b) with BSF

By increasing the level of flaxseed flour it was noticed by the panelists an increased of the overall acceptability for the bread samples up to 10-15% flaxseed addition. At levels of 10-20% flaxseed addition were not obtained such significant differences between the samples the results being closer from the overall acceptability point of view. Therefore a partial replacement of wheat flour up to about 20% with flaxseed is possible in order to produce bread well appreciated by the consumers no matter of the variety of flaxseed used.

G. Prinicipal Component Analyisis of the Alveograph Characteristics, Bread physical, Textural and Sensory Characteristics

In Fig. 5 is shown the Principal Component Analysis (PCA) in order to highlight the relationship between the chemical characteristics of wheat flour-flaxseed formulation, Alveograph rheological parameters, textural and sensory characteristics of bread samples obtained at different addition levels of 0, 5, 10, 15 and 20% of GSF and BSF in wheat flour. The first principal component PC1 is strongly correlated with bread sensorial characteristics smell, taste and flavor between are high correlations (r=0.761 and respectively r=0.828). also a strong correlation were found between textural characteristic elasticity and the physical one (r=0.823). The second component PC2 indicated good correlations between generall appearence and overall accepatability, between (r=0.801) hardness and protein content (r=0.723) and inverse coorelations between protein content and baking strength (r=-0.956, p=0.01).

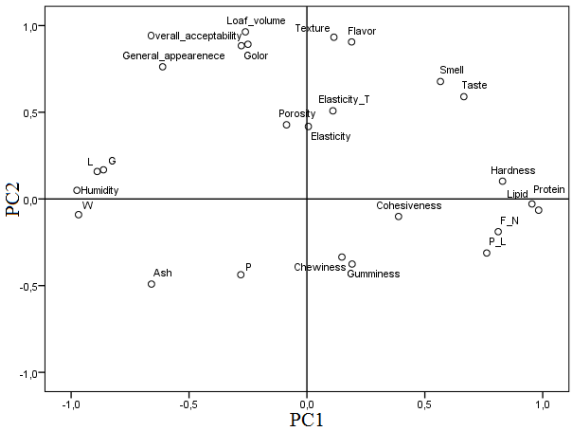

Figure 5. Principal component analysis for the flaxseed-wheat flour chemical characteristics, dough and bread quality values

IV. Conclusions

Wheat flour substituted with 10% golden flaxseed flour addition and 15% brown flaxseed flour addition produced the most acceptable composite flour bread from the sensorial and physical point of view. Even if the flaxseed level in wheat flour increase the bread was acceptable from the sensorial point of view, a partial replacement of wheat flour up to 20% with flaxseed being possible and acceptable by the consumers. Addition of flaxseed decreased dough extensibility and baking strength from the Alveograph point of view and increase the hardness textural parameter value. Regarding the correlations obtained with the Principal Component Analysis good correlations were found between sensorial characteristics taste, smell and flavor and between generall appearence and overall accepatability. Also an inverse coorelation were found between protein content and baking strength.

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References

[1] V. J. Barthet, D. Klensporf-Pawlik, and R. Przybylski, "Antioxidant activity of flaxseed meal components," *Canadian Journal of Plant Science*, vol. 93, pp. 593-602, 2014.

[2] M. Ali, F. U. Hasan, and M. Afzal, "Response of Linola (Linum usitatissimum L.) to different spacings under rainfed conditions," *Cercetări agronomice în Moldova*, vol. 166, pp. 86-96, 2016.

[3] B. D. Oomah, "Flaxseed as a functional food source," *J. Sci. Food Agric.*, vol. 81, pp. 889-894, 2001.

[4] M. Friedman and C. E. Levin, "Composition of Jimson weed (*Datura stramonium*) seeds," *J. Agric. Food Chem.*, vol. 37, pp. 998-1005, 1989.

[5] S. C. Sargi, B. C. Silva, *et al.*, "Antioxidant capacity and chemical composition in seeds rich in omega-3: Chia, flax, and perilla," *Food Sci. Technol.*, vol. 33, pp. 541–548, 2013.

[6] P. S. Epaminondas, K. L. G. V. Araujo, *et al.*, "Influence of toasting on the nutritious and thermal properties of flaxseed," *J. Therm. Anal. Calorim.*, vol. 106, pp. 551–555, 2011.

[7] P. M. Ganokar and R. K. Jain, "Flaxseed-a nutritional punch," *Int. Food. Res. J.*, vol. 20, pp. 519-525, 2013.
[8] Y. Y. Shim, B. Gui, P. G. Arnison, Y. Wang, and M. J. T. Reaney, "Flaxseed (*Linum usitatissimum L.*) bioactive compounds and peptide nomenclature: A review," *Trends in Food Sci. Tech.*, vol. 385, pp. 5-20, 2014.
[9] S. J. Cameron and F. Hosseinian, "Potential of flaxseed in the development of omega-3 rice paper with antioxidant activity," *LWT - Food Sci. Technol.*, vol. 53, pp. 170-175, 2013.
[10] M. Hao and T. Beta, "Development of Chinese steamed bread enriched in bioactive compounds from barley hull and flaxseed hull extracts," *Food. Chem.*, vol. 133, pp.1320-1325, 2012.
[11] P. P. Rao, G. N. Rao, K. Mala, K. Balaswamy, and A. Satyanarayana, "Preparation and storage stability of flaxseed chutney powder, a functional food adjunct," *J. Food Sci. Technol.*, vol. 50, pp.129-134, 2013.
[12] A. Goyal, V. Sharma, N. Upadhyay, S. Gill, and M. Sihag, "Flax and flaxseed oil: an ancient medicine & modern functional food," *J Food Sci. Technol.*, vol. 51, pp. 1633-1653, 2014.
[13] A. Kaur, V. Sandhu, and K. S. Sandhu, "Effects of flaxseed addition on sensory and baking quality of whole wheat bread," *International Journal of Food Nutrition and Safety*, vol. 4, pp. 43-54, 2013.
[14] T. Rakcejeva, L. Skudra, and E. Strautniece, "Sensory evaluation of wheat bread with flax seed marc additive," *Maisto Chemija ir Technologija*, vol. 41, pp. 58-62, 2007.
[15] S. Mironeasa and G. G. Codină, "Optimization of a strong wheat flour quality with a low alpha-amylase content by using response surface methodology," *Journal of Food Studies*, vol. 3, pp. 15-24, 2014.
[16] G. G. Codină, S. Mironeasa, and C. Mironeasa, "Variability and relationship among Mixolab and falling number evaluation based on influence of fungal alpha-amylase addition," *Journal of the Food Science and Agriculture*, vol. 92, pp. 2162-2170, 2012.
[17] R. Meral and I. S. Dogan, "Quality and antioxidant activity of bread fortified with flaxseed," *Italian Journal of Food Science*, vol. 25, pp. 51-56, 2013.
[18] Y. Xu, C. A. Hall, and F. A. Manthey, "Effect of flaxseed flour on rheological properties of wheat flour dough and on bread characteristics," *Journal of Food Research*, vol. 3, pp. 83-91, 2014.

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